Advancement in Analysis of Welded Structure

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Abstract

The weldabilityrefers to its ability to be welded. Metallic material is considered to be susceptible to welding to an established extent with given processes and for given a corresponding technological process for welded parts as to their own qualities as well as to their influence on a structure they form. Titanium is a unique material, as strong as steel but half its weight with excellent corrosion resistance, at temperatures above 500°C; titanium has a very high affinity for oxygen, nitrogen and hydrogen. Whether at macro-, micro- or Nano- scale, providing mechanical support and integration, electrical connection, optical coupling, environmental protection, the exception to this metallurgical definition is mechanical joining (fastening, riveting, crimping. Femtosecond laser irradiation can be used to obtain ultrafast non thermal melting of solid materials. Nano scopic joining is finding wider applications. It has a significant effect on the cost, quality, performance and reliability of the fabrication. Totally new evolution of materials gives way to revolution to meet unimagined new designs and design demands and safety having an impact on future growth in welding technology. Replacement technologies such as polymer bonding, adhesive bonding, and abrasion are being developed.

Keywords: titanium alloy, pipe work, Nano joining, constraints for design, performance and reliability.

Introduction

Metal industries use a variety of methods to join different components and the joining methods can be either permanent or temporary depending on the type and design of the product. The latter methods use parts like bolts, screws, and rivets, whereas permanent joining usually involves welding. Welding is one of the most common joining processes in the metal industry, applied in facilities from job shop outfits to highly-automated computer- controlled factories. Another important determinant of the future of welding is the drive to improve efficiency and productivity. For manufactured products to be able to compete, they must be made faster, cheaper, and better than those of competitors. Continuing growth in welding equipment purchases shows that worldwide utilization of welding is still increasing and its use is expected to grow further due to its economic advantages. For the foreseeable future, intelligently designed weld metals will always be less expensive.

Metallic material is considered to be susceptible to welding to an established extent with given processes and for given purposes when welding provides metal integrity by a corresponding technological process for welded parts to meet technical requirements as to their own qualities as well as to their influence on a structure they form.

Current Trends in Welding Processes and Materials: Improvement in Effectiveness

Demands for improved productivity, efficiency, and quality pose challenges to the welding industry to provide ever- better functionally specific properties, a more complete and precise understanding of how such materials can be joined for optimal effectiveness and efficiency will become essential. In addition, totally new methods emerge as evolution of materials gives way to revolution to meet unimagined new designs and design demands, future direction of welding technology, welding materials, productivity and

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efficiency, education and safety having an impact on future growth in welding technology.

Welding Processes

Arc welding:A basic advantage of arc welding is of low cost, convenience, and extremely wide applicability. Technological innovation aimed at increases in productivity, stabilization of weld quality and labor saving. fusion welding processes, flexibility and cost effectiveness, it is an indispensable technology for the construction of steel- framed buildings, ship building, motor vehicle manufacture, power plants and other industries.

Gas metal arc welding (GMAW): GMAW is utilized as a semi- mechanized, fully mechanized or automatic process. Developments with regard to controlled energy input as a cold arc or as cold metal transfer (CMT) have attracted attention in recent times. Metal transfer of short arc welding processes is controlled by reducing the current during the short circuit phase or by pulling back the wire during or just after metal transfer. These control methods permit very low- spatter welding and also the welding of materials which can only withstand a low heat supply or low energy supply such as highest- strength or surface- coated steels. It is to be expected that GMAW will continue to evolve to allow better arc control, better bead contour control, better deposition control (i.e. out-of- position welding and thermal management), and higher productivity (through faster deposition and fewer defects as a continuous wire process with high filler metal utilization, it is an alternative for shielded metal arc welding, gas welding, brazing, and resistance welding.

Submerged arc welding (SAW): The submerged arc welding process, in which the weld and arc zone are submerged by a layer of flux, is the most efficient fusion welding process in plate and structural work such as shipbuilding, bridge building, and pressure vessel fabrication, assuming the work pieces can be properly positioned and the equipment accurately guided. The optimum process is selected based on a compromise between welding speed (deposition rate), versatility, and portability.

Gas Tungsten Arc Welding (GTAW): GTAW is a process that uses a non consumable electrode to heat the work piece to be welded. It is to be expected that GTAW will grow at a rate matching growth in the total welding market. The main reasons for this development are: i) it is adaptable to automation; ii) it is used on high quality work; and iii) it is suitable for welding newer thin specialty metals. However, the technique is unlikely to become a large segment of the total welding. Flux- assisted gas tungsten arc welding is being explored to allow reactive metals (like Ti) to be welded or repaired in the field; building on developments already achieved. Variations of the plasma arc welding process also may provide new capabilities for arc welding advanced materials.

Flux cored arc welding (FCAW): FCAW is a process that uses an arc between a continuous filler metal electrode and the weld pool. Shielding gas from a flux contained within the tubular is used in the process . FCW welding is used for the fillet. This welding has come into use not only for 490 N/ mm2 grade steel and 590 N/mm2 grade steel but also for weather- resistant steel. FCW, with which upward welding is possible at high currents, is used when the gap is large.

Beam welding technology: Electron beam welding has been applied increasingly and has been able to bring its advantages to bear. These advantages are an extremely high power density and thus a low heat input even in the case of the thickest welds of up to 250 mm and above. The availability of large vacuum chambers, up to 630 m3, permits the welding even of large- volume machine components. The possibility of splitting the beam allows the execution of several welds on one component at the same time. *Laser beam welding has the great advantage that it can be used outside a vacuum but in general it is only suitable for material thicknesses below 25 mm.* The process is suitable for the manufacture of tailored blanks of different steel qualities and material thicknesses and high energy density. By means of remote techniques, it is possible to use the effect of the laser beam over relatively long distances between the beam source and the welding position (up to 500 mm). It is to be expected that laser beam welding will be increasingly used in automobile fabrication. It will also be utilized in the processing of plastics because of requirements with regard to the light absorption of the plastics to be processed.

Friction and Resistance Welding Processes

friction welding machine technology have led to the use of the lateral relative movement of the parts to be welded so that the technique can be utilized for joining large sections which are not rotationally symmetrical. One special variant of friction welding is friction stir welding (FSW), which at the moment is used exclusively for aluminum and its alloys.

The advantage of friction and resistance welding processes is that the welding is carried out below the melting temperature and thus the welding leads to only a slight metallurgical change in the base materials to be joined. Friction stir welding is currently utilized in rail vehicle construction, the aerospace industry, and for the leak- tight welding of covers into hydraulic control parts. Resistance welding will continue to advance rapidly (with pressure from the automobile industry to weld higher strength steels and Al alloys) with improvement in inverter power supplies,

Improvement in Effectiveness

Improved process regulation or control, and improved quality assurance. Improvements in machine control and computer technology have made different process variants (flash butt welding, stud welding, etc.) more reliable.

Hybrid Welding Technology

Hybrid welding is a combination of an arc welding and the laser welding in the same weld pool. The combination of arc metal welding with laser beam welding has been introduced into practice at a particularly quick speed (shipbuilding and automobile construction), and is reflected in the expectation of a greater degree of utilization in practice. The combination results in very positive characteristics such as high energy density and low thermal load, high welding speed, deep penetration and high tensile strength, good gap-bridging capacity, and the possibility of the addition of filler metal and metal microstructure modification. It is possible to weld greater wall thicknesses in one pass, which gives considerable economic benefits now and in the future. This process has been applied mostly in the welding of steel. Specific advances will include continued development of dual- (or multiple-) beam welding, deep welding using higher power sources and special gas assists, further development of hybrid welding processes (like laser- GTA and laser-GMA, laser- PAW, laser- submerged, Laser-tandem). Beyond, but related to, welding will be continued development and application of targeted surface modification (i.e. heat treatment, glazing, texturing); cutting, drilling, and machining; and rapid prototyping. Similar advances will likely occur with plasma- based systems. Plastics welding (including welding of thermoplastic-matrix composites) will continue to advance as thermoplastics and thermoplastic- matrix composites continue to proliferate and advance. New processes include: high frequency welding, thermal impulse welding, hot bar welding, vibration and ultrasonic welding, and focused IR welding.

Welding Materials

For every new material developed, joining processes must be restudied or developed to use the material effectively. Use of new materials will be limited by the capability to exploit the joining processes, rather than by the ability to design or produce such materials. The present direction of improvement of welded structures is a decrease of their weight and energy requirement in fabrication, and improvement of consistency and endurance.

Development of Materials

Welding and materials engineers need to develop new materials and adapt existing materials so that they are specifically designed to be welded into world- class, fabricated products. Furthermore, there is a need to seek higher- performance materials; match the material with the joining processes and advanced consumables of the application; stimulate development of product designs and new technologies and materials for welding; adapt certain alloys as weldable materials; increase access to information on the attributes of welding; integrate materials, processes, sensors and controls; and develop long-lasting, reliable, corrosion- resistant materials that do not require pre- heating. As materials are developed with increased strength, corrosion resistance, and other performance factors, welding of such materials can become more and more difficult. Special filler metals, pre- and post- weld heat treatment, and other techniques make welding feasible in many cases, but at substantially increased cost.

Titanium and Titanium Alloys

Titanium is a unique material, as strong as steel but half its weight with excellent corrosion resistance. It has high strength to weight ratio; corrosion resistance; mechanical properties at elevated temperatures.

Material Types

Titanium - Commercially pure (98 to 99.5% Ti) or strengthened by small additions of oxygen, nitrogen, carbon and iron. The alloys are readily fusion weldable.

- Alpha alloys
- Alpha- beta alloys

Alloys which contain a large amount of the beta phase, stabilized by elements such as chromium, are not easily welded.

At temperatures above 500°C, titanium has a very high affinity for oxygen, nitrogen and hydrogen. The weld pool, heat affected zone and cooling weld bead must be protected from oxidation by an inert gas shield (argon or helium).

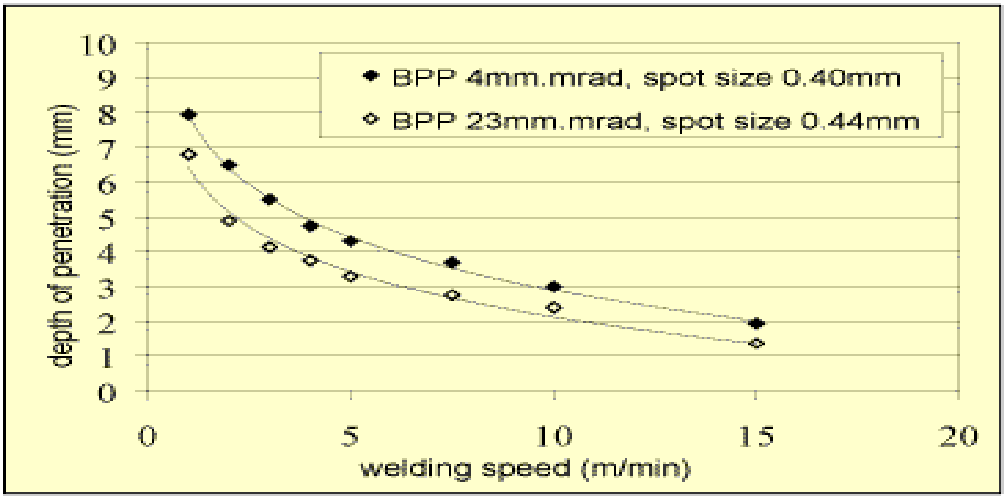

Figure 1.Effect of Titanium- Diboride

Titanium- Diboride Reinforced Graphite Aluminum Composites

The study of frictional forces of interacting surfaces, known as tribology, plays a vital role in friction and lubrication- dependent machining processes. Using Graphite reinforcement in aluminum matrix composites has been reported to be beneficial in reducing wear due to its solid lubricant property, but results in reduction of strength. Adding Titanium diboride to aluminum matrix composites reinforced with graphite will improve both mechanical strength and wear resistance of composite and resulting in a hybrid composite. Sintered Aluminum matrix composites with Titanium diboride were developed for wear applications. Composites with base material of commercial aluminum of 98% purity and 5wt% Graphite, containing various levels of Titanium diboride (5 to 20 wt %) were developed.

The widely applied methods for the production of composite materials are based on casting techniques. The machining difficulties and processing costs related to particle reinforced aluminum matrix composites have limited the application range of these advanced materials. The volatile material properties of aluminum based particle reinforced composites are increased stiffness, wear resistance, specific strength and vibration damping, and decreased coefficient of thermal expansion compared with conventional aluminum alloys.

The material holds the reinforcement to form the desired shape while the reinforcement improves the overall mechanical properties of the matrix. When designed properly, the new combined material exhibits better strength than would each individual material.

Micro joining to Nano joining

Nano joining examples are given and analyzed in various joining categories such as solid- state bonding, soldering/ brazing and fusion welding. Some proposed strategies for Nano assembly and Nano joining are self- organization and inkjet printing.

Joining (welding, brazing, soldering, bonding, etc.), whether at macro-, micro- or Nano- scale, is an essential step of man- made product manufacturing and assembly, providing mechanical support and integration, electrical connection, optical coupling, environmental protection, etc. -, micro- and Nano- sized building blocks to be assembled. The continuing miniaturization of engineered devices and systems, coupled with ever- growing demands for cost reduction, enhanced performance and reliability, etc. Joining of material up to a few hundred nanometers could be called Nano joining. Micro joining would deal with parts with characteristic dimension smaller than a few hundred micrometers but larger than hundreds of nanometer.

Applications

- Microelectronics, medical, aerospace, and defense industries,
- Ultrasonic welding: Regular joining and micro joining, to join CNTs to Ti electrodes.
- Cold Nano welding: To join ultrathin single-crystal Au nanowires at close to room temperature with scanning tunneling microscope strength reached ~600 MPa, comparable to that of the original nanowire.

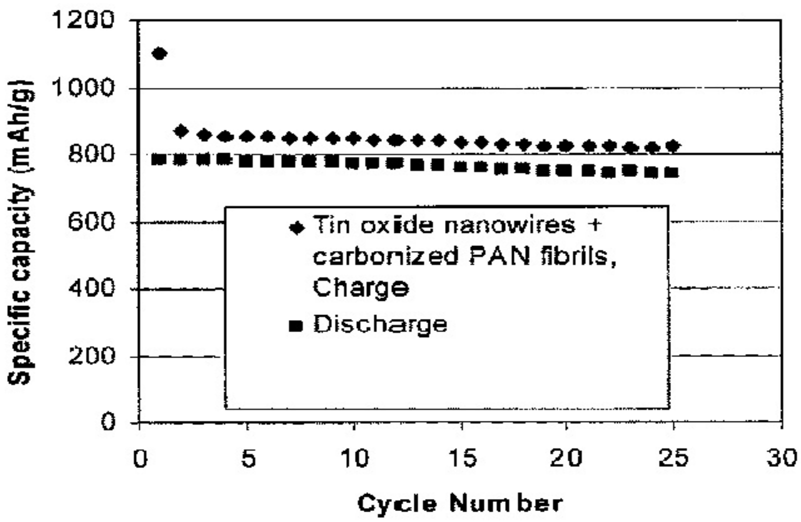

Figure 2.Load capacity of Micro joining

Nano joining is emerging only recently but developing rapidly, and is considered as one of the key technologies in industrially successful Nano-devices and Nano- systems. As new and innovative Nano joining processes continue to emerge, understanding will grow as to whether the traditional classification, in terms of solid- state bonding, fusion welding, brazing/ soldering and adhesive bonding, can survive at the nanoscale. Whether completely new or modified from microjoining (or even from macrojoining/ regular joining processes), nanojoining processes face challenges because of ever- miniaturizing building blocks

Developing appropriate assembly and nanojoining strategies is vital for commercially successful applications of nanodevices and nanosystems, such as micro- electro- mechanical systems (MEMS) and nano- electro- mechanical systems (NEMS). It is also expected that underlying physical and chemical phenomena may differ in many nanojoining processes even though they share technological resemblance to their counterparts in micro- and macro- joining. For example, it has been reported that transport mechanisms switch half- way through the sintering process of metallic nanoparticles, e.g., from surface diffusion to grain boundary diffusion.

Efficiency and Productivity

Efficiency is the extent to which time or effort is well used for the welding tasks. The search to reduce costs is driving industries to improve the efficiency of welding, by shifting equipment from manual to semiautomatic to fully automatic welding. By using robots, the human factors that reduce efficiency in welding are rectified. Increased productivity is achieved through a higher operator factor; a higher deposition factor; a higher welding speed; good, uniform and consistent quality; strict cost control through predictable weld times; minimized operator skill requirements; reduced training requirements; and better weld appearance and consistency of product. Currently, automation is the single most important growth sector in the welding industry. The drive for higher productivity and reduced costs will keep automation at the forefront. Other reasons for the increasing use of automation include safety concerns and efforts to free welders from tiring, repetitive conditions and long- term exposure to fumes. Automatization and robotization are beginning to be taken as key technologies to secure improved productivity and consistent quality.

The main topics of the Working Group are the following:

• To elaborate new cost functions for cost minimization
• To use stability, stress, deflection, etc. constraints for design
• To introduce new structural models
• To use new mathematical models, finding the best

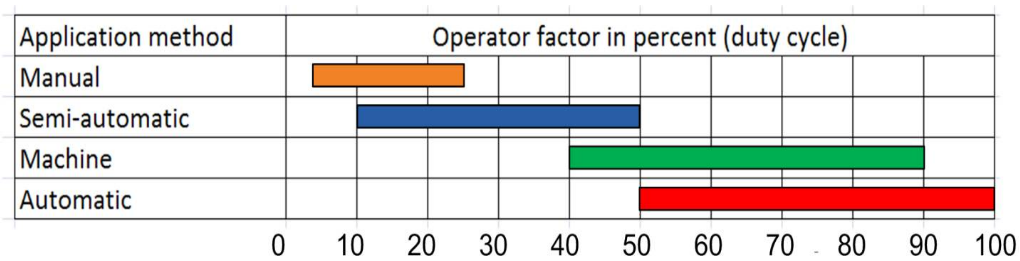

Figure 3.Effect of mechanization on operator factor

Welding Quality Management

Welding is a special process which has a significant effect on the cost, quality, performance and reliability of the fabrication e.g. pressure vessel, pipe work.

Methods

- New and Replacement Equipment
- Repairs or Alterations to Existing Equipment
- Tasks & Responsibilities

Education, Safety and Health

For welding to achieve its potential as a preferred state- of- the- art manufacturing process, the scientific and engineering principles behind welding may be more effective apprentice programs for welders and technicians. It is expected that welding as a vocation will gain a higher level of prestige.

Welding needs safety from:

- Fire and explosion
- Lack of oxygen in confined spaces
- Electrical hazards

Health Hazard

- Illness caused by welding fume and gases
- Welding fume facts
- Welding fume - Reducing the risk
- Welding fume - Do you need extraction or RPE?
- Noise and vibration
- Manual handling

Conclusions

Although this paper does not cover all developments, and the discussions are necessarily limited, the technologies discussed are, however, to some extent, all already practiced in industrial applications. The main findings can be summarized as in the list below.

1. Materials of the future will be designed to be weldable as part of the total integration of welding into the manufacturing cycle. They will also be energy efficient and environmentally benign.
2. The use of modeling, systematic process selection and procedure development, and non destructive examination technologies will ensure Current trends in welding processes and materials: improve in effectiveness.
3. There will be a trend towards higher levels of reliability and higher- quality requirements. The trend towards automatic welding and automation in welding will accelerate.
4. Welding methods such as laser welding, laser- arc hybrid welding and friction stir welding will become far more significant as a

result of the rapid transfer of findings from research to application.

5 Their quality, mechanical properties and weldability will be improved as a result of decreasing the content of harmful impurities, finding new alloying systems, increasing the sensitivity of heat treatment, and increasing corrosion resistance in different media. Special attention will be given to the development of new types of high strength low alloy steels, including those with a very low carbon content, heat resisting steels, steels of structures operating at low climatic temperatures, cryogenic applications and high alloy steels for different purposes.

6 Further work will be carried on the development of aluminum high strength alloys, titanium alloys and other types of new structural materials because of their greater strength to weight ratios and high temperature resistances. (AMMCs) have been well recognized and steadily improved because of their advanced engineering properties, such as their improved wear resistance, low density, specific strength and stiffness

7 The design of welding materials may be considered to play the most important role in improving the quality of the welds and maintaining the reliability of structures. The training of welding technicians with this approach will be of the greatest future importance.

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